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VARIATION OF HYDRODYNAMIC IMPACT LOADS WITH FLIGHT-PATH ANGLE FOR A PRISMATIC FLOAT AT 3° TRIM AND WITH A $22\frac{1}{2}^{\circ}$ ANGLE OF DEAD RISE

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VARIATION OF HYDRODYNAMIC IMPACT LOADS WITH FLIGHT-PATH ANGLE FOR A PRISMATIC FLOAT AT 3° TRIM AND WITH A $22\frac{1}{2}^{\circ}$ ANGLE OF DEAD RISE

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SUMMARY

Tests were made in the Langley impact basin to determine the relationship between impact normal acceleration and flight-path angle for seaplanes landing on smooth water. The tests were made at both high and low forward speeds with the model at 3° trim. The model had a dead-rise angle of $22\frac{1}{2}^{\circ}$ and, with the drop linkage, weighed 1100 pounds. The results of the tests indicated that the maximum impact normal acceleration was proportional to $\gamma^{1.36}$ over the test range of flight-path angle γ and that the effects of gravity forces appeared during the immersion process after the maximum impact normal acceleration had occurred.

INTRODUCTION

The time history of the impact acceleration that occurs during symmetrical smooth-water landings of a seaplane is dependent upon three principal flight parameters: velocity, flight-path angle, and trim. The variation of impact normal acceleration with resultant velocity is presented in reference 1. It has heretofore been impossible to establish experimentally the relationship between impact load and flight-path angle. Data derived from tests of full-scale airplanes have not been applicable to the problem of determining this relationship because of insufficient accuracy in the measurement

of the test parameters. The Langley impact basin, however, affords controlled as well as accurate means for obtaining data relevant to this problem (reference 1). Tests were made in the Langley impact basin to determine an empirical variation of impact normal acceleration with flight-path angle within the range of smooth-water landings. The results of these tests, which included runs at both high and low speeds, are representative of a prismatic form because the model (reference 1) was tested without the afterbody. The effect of trim is not included in the present report since all runs were made with the model at 3° trim.

SYMBOLS

V	resultant velocity of float, feet per second
V_h	horizontal velocity component of float, feet per second
V_v	vertical velocity component of float, feet per second
g	acceleration of gravity (32.2 ft/sec^2)
γ	flight-path angle, degrees $\left(\tan \gamma = \frac{V_v}{V_h}\right)$
y	vertical displacement of float, inches
F_i	impact force, pounds
W	total dropping weight, pounds
n_i	impact load factor, g $\left(\frac{F_i}{W}\right)$
τ	float trim, degrees

EQUIPMENT AND INSTRUMENTATION

The model tested (fig. 1) was the forebody of the float described in reference 1, which has an angle of dead rise of $22\frac{1}{2}^{\circ}$. The dropping weight of the model was held at 1100 pounds throughout the tests. The instruments

and equipment used throughout were the same as those described in reference 1, except that an NACA air-damped accelerometer with a natural frequency of approximately 21 cycles per second replaced the galvanometer-type accelerometer previously used.

TEST PROCEDURE

The tests included two series of runs: the first at a forward speed of approximately 98 feet per second and the second, at approximately 45 feet per second. The trim and yaw angle were held constant throughout the tests at 3° and 0°, respectively; whereas the vertical velocity was varied to give an approximate range of V_v/V_h from 0.015 to 0.130 for each series of tests. The depth of immersion was measured at the step. During the impact process, a lift equal to the dropping weight was exerted on the float by means of the buoyancy engine described in reference 1. All test measurements were recorded as time histories.

PRECISION

The apparatus used in the present tests give measurements that are believed correct within the following limits:

Horizontal velocity, ft/sec	±0.5
Vertical velocity, ft/sec	±0.2
Vertical displacement, in.	±0.2
Acceleration, g	±0.5
Weight, lb	±2.0

RESULTS AND DISCUSSION

The maximum normal load factor for each impact was derived from the accelerometer record for each run. Inasmuch as the buoyancy engine contributed a force equal to the dropping weight, 1 g was subtracted from the accelerometer record to isolate the hydrodynamic force resulting from the impact. Because the maximum

impact normal acceleration was shown in reference 1 to be proportional to the square of the resultant velocity, the hydrodynamic load factor was divided by V^2 to eliminate the effects of velocity. The values of $n_{i_{max}}/V^2$ thus obtained are plotted in figure 2 against the flight-path angle at the instant of water contact. Within the scatter of the test points, the variation of $n_{i_{max}}$ with γ is an exponential function over the test range. Evaluation of the slope of the curve in figure 2 shows that for 3° trim

$$n_{i_{max}} \propto \gamma^{1.36}$$

Maximum depth of immersion and depth of immersion at the time of $n_{i_{max}}$ are plotted against the flight-path angle in figure 3. The curves representing the immersion at maximum n_i for the two velocity series coincide and thereby show no effect of velocity; however, the curves for maximum immersion show a definite separation and thus indicate a velocity effect during this period. It is quite easy to show that the maximum depths of immersion for impacts of equal flight-path angles but different velocities are the same provided the acceleration at any instant is proportional to the square of the velocity and all other parameters are assumed constant. The instantaneous impact accelerations result from a summation of dynamic forces and gravity forces, both of which vary in magnitude during different stages of immersion. The dynamic forces are proportional to V^2, but the gravity forces do not follow the V^2 law. It is therefore evident from figure 3 that the effects of gravity forces, which are a function of Froude's number, become apparent during the immersion process some time after the maximum normal impact acceleration has occurred. The accuracy of the data, however, is insufficient to permit evaluation of the magnitude and extent of this effect.

CONCLUSIONS

Tests were made in the Langley impact basin to determine the relationship between the impact normal

acceleration and flight-path angle for seaplanes landing on smooth water. The results of the tests, which were made at constant weight and 3° trim, indicated the following conclusions:

1. The maximum impact normal acceleration was proportional to $\gamma^{1.36}$ over the test range of flight-path angle γ.

2. The effects of gravity forces appeared during the immersion process after the maximum impact normal acceleration had occurred.

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REFERENCE

1. Batterson, Sidney A.: The NACA Impact Basin and Water Landing Tests of a Float Model at Various Velocities and Weights. NACA ACR No. L4H15, 1944.

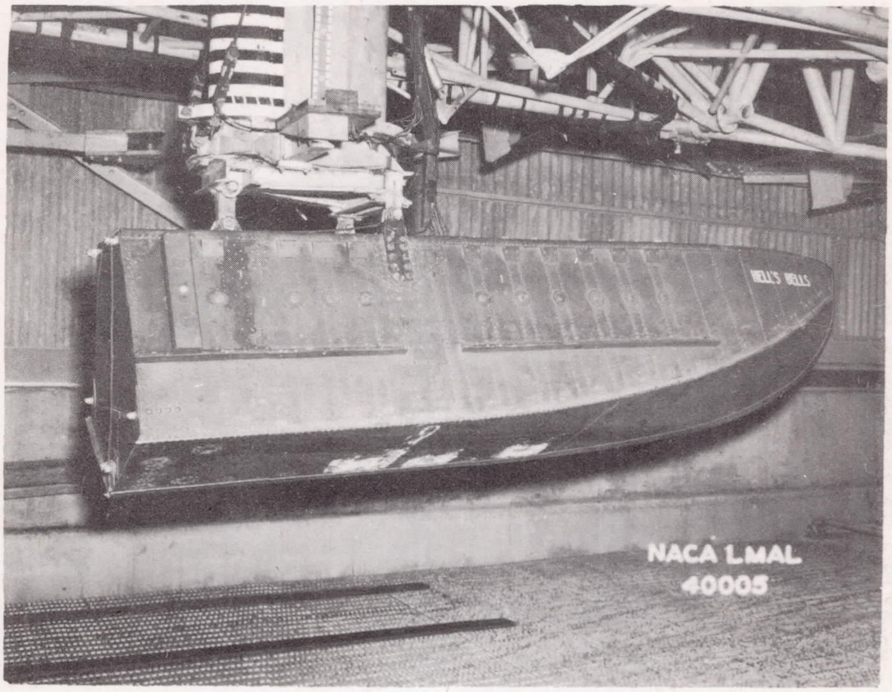

Figure 1.- Side view of model fastened to boom in Langley impact basin.

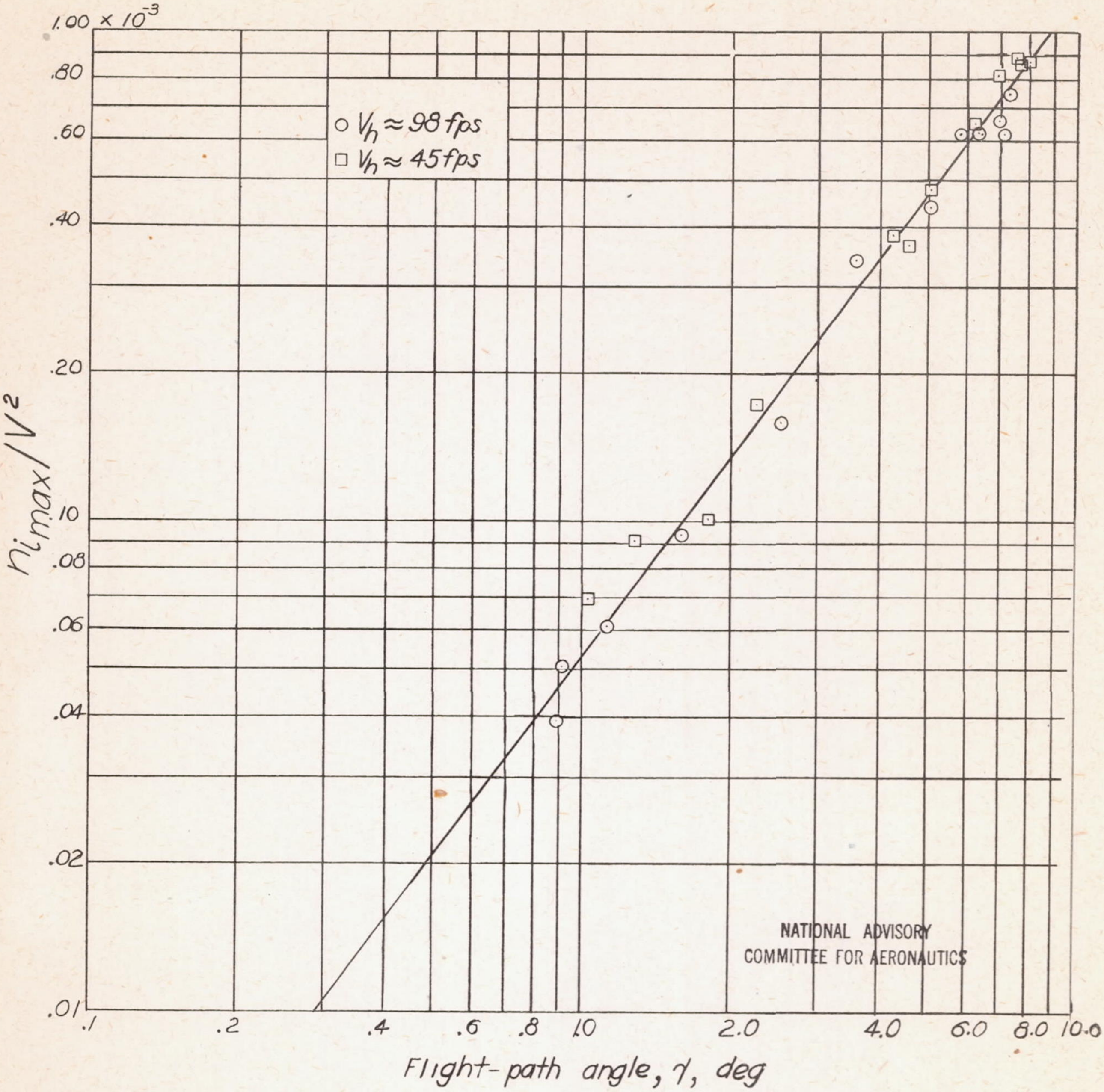

Figure 2.- Variation of the parameter $n_{i_{max}}/V^2$ with flight-path angle. $\tau = 3^\circ$.

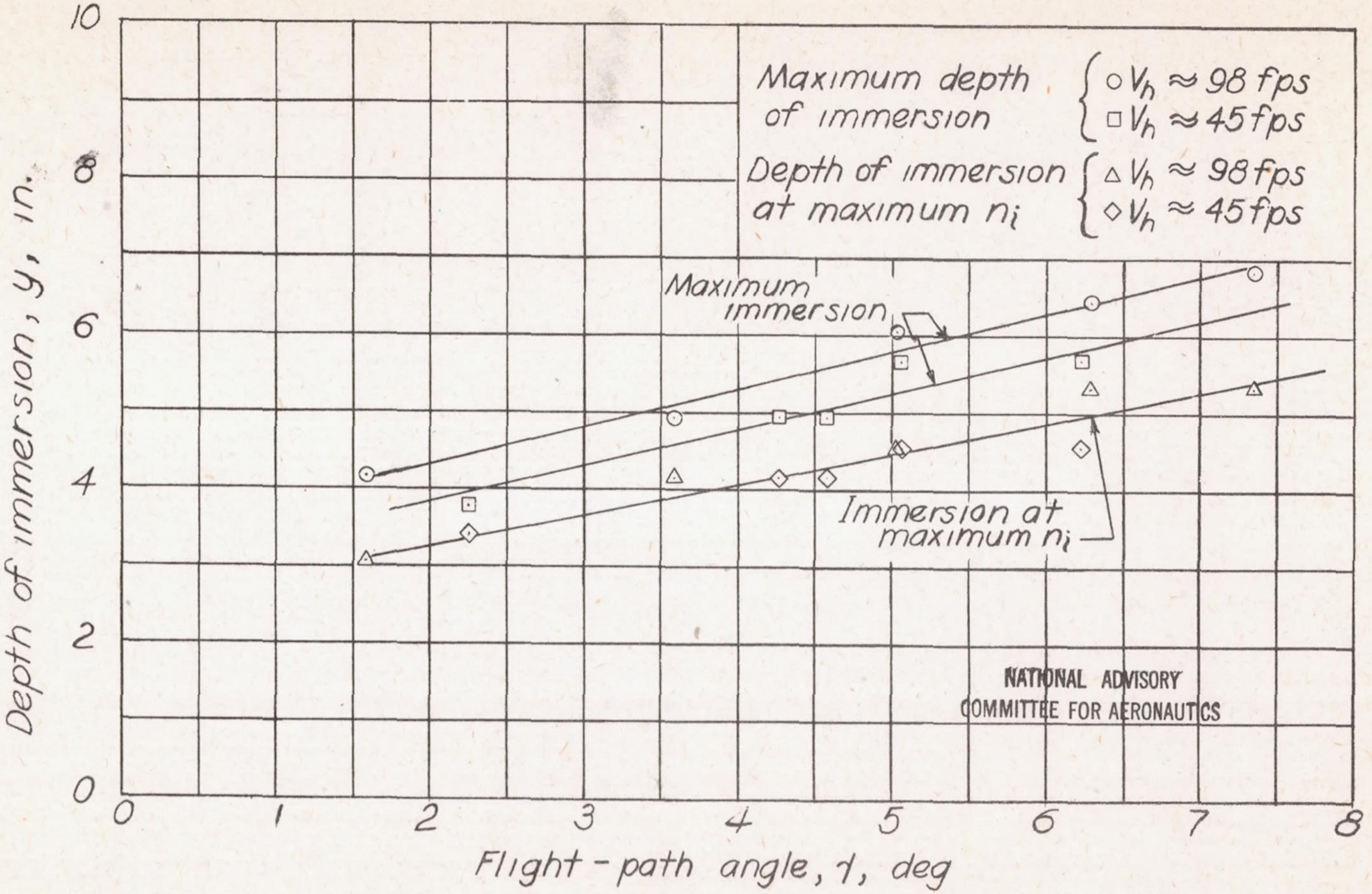

Figure 3. - Variation of maximum depth of immersion and immersion at time of maximum impact acceleration with flight-path angle at horizontal velocities of approximately 98 and 45 feet per second. $\tau = 3°$.